PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference RESE-PA0304WO	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. PCT/EP2004/052913	International filing date *(day/month/year)* 10.11.2004	Priority date *(day/month/year)* 12.11.2003
International Patent Classification (IPC) or national classification and IPC INV. G02B6/12 C03C3/04		
Applicant IGNIS TECHNOLOGIES AS		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 13 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 9 sheets, as follows:
      ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in celectronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

☒	Box No. I	Basis of the report
☒	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☒	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of this report
09.09.2005	10.03.2006
Name and mailing address of the international preliminary examining authority: European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized officer Cohen, A Telephone No. +31 70 340-2265

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/EP2004/052913

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
   - ☐ international search (under Rules 12.3 and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4)
   - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages	
1-40	as originally filed
Claims, Numbers	
1-55	amended under Art.34
Drawings, Sheets	
1/5-5/5	as originally filed

   ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

Box No. II Priority

1. ☐ This report has been established as if no priority had been claimed due to the failure to furnish within the prescribed time limit the requested:
   - ☐ copy of the earlier application whose priority has been claimed (Rule 66.7(a)).
   - ☐ translation of the earlier application whose priority has been claimed (Rule 66.7(b)).

2. ☐ This report has been established as if no priority had been claimed due to the fact that the priority claim has been found invalid (Rule 64.1). Thus for the purposes of this report, the international filing date indicated above is considered to be the relevant date.

3. Additional observations, if necessary:

   see separate sheet

Box No. IV Lack of unity of invention

1. ☐ In response to the invitation to restrict or pay additional fees, the applicant has:
   - ☐ restricted the claims.
   - ☐ paid additional fees.
   - ☐ paid additional fees under protest.
   - ☐ neither restricted nor paid additional fees.

2. ☒ This Authority found that the requirement of unity of invention is not complied with and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

   ☐ complied with.

   ☒ not complied with for the following reasons:

   see separate sheet

4. Consequently, this report has been established in respect of the following parts of the international application:

   ☒ all parts.

   ☐ the parts relating to claims Nos. .

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	8,10,12,18-23,28-52,54,55
	No:	Claims	1-7,9,11,13-17,24-27,53
Inventive step (IS)	Yes:	Claims	18,19,31,36,47,51
	No:	Claims	1-17,20-30,32-35,37-46,48-50,52-55
Industrial applicability (IA)	Yes:	Claims	1-55
	No:	Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Re Item II

The subject-matter of dependent claims 34-36, 39-41, 50 and 55 (and the following corresponding passages of the description and drawings: p. 6 lines 26-28, p. 9 lines 17-20, p. 17 lines 16-31, p. 19 lines 31-34, p. 20 lines 9-25, p. 21 line 20 - p. 22 line 9, p. 22 line 20 - p. 23 line 4, p. 24 lines 4-9, p. 30 line 25 - p. 32 line 25, Figures 7a, 7b and 8) is not contained in the priority document (Danish filing PA 2003 01686, 12 November 2003), and therefore priority rights with effect from the date of the priority document are not validly claimed. Consequently, priority rights with regard to said claims may only be validly claimed with effect from the date of the filing of the PCT application (10 November 2004).

Re Item IV.

1. The separate inventions/groups of inventions are:

   I. Claims 1-30, 32-46, 48-50, 52-55
   Silicon oxynitride waveguide comprising phosphorous and boron or germanium, or a combination of all three elements; or comprising germanium plus an element selected from the group B, Al, P, S, As, Sb.

   ii. Claim 31
   Silicon oxynitride waveguide comprising a dopant selected from the group B, Al, P, S, As, Sb and additionally a dopant for control of thermal expansion selected from the group Al, F, Ti.

   iii. Claims 47 and 51
   Method of manufacturing a silicon oxynitride waveguide by PECVD in which the silane flow is restricted to be in the range 0-30 sccm.

   They are not so linked as to form a single general inventive concept (Rule 13.1 PCT) for the following reasons:

2. The following documents are referred to:

D1: WO 99/44937
D2: US2002/154878
D3: JP 9080247

2.1 Lack of novelty (Article 33(2) PCT) and/or inventive step (Article 33(3) PCT) of the independent claims:

The document D1 (references thereto are given in parentheses) discloses all the features of amended claim 1 as interpreted in the light of the lack of clarity thereof (see under Item V), namely an optical waveguide comprising core and cladding regions, the core and cladding region being formed on a substrate (pages 1-2), and the whole or a part of the core and/or cladding region comprising material of the stoichiometric composition $Si_aO_xN_yX_zH_v$, wherein X is P (phosphorus), and wherein
a is in the range from 0.1 to 3.5;
x is in the range from 0 to 2.5 [excluding zero];
y is in the range from 3.9 to 4.1 or in the range from 0.02 to 0.3;
z is in the range from 0 to 0.3 (formula at page 15, line 15);
and the ratio y/z is larger than 1.2 (page 15, lines 6-16, specifically "the over- or under-roping concentration (z-y) may be greater or smaller than zero").

The subject-matter of claim 1 is therefore not new (Article 33(2) PCT).

The document D2 (references thereto are given in parentheses) discloses the following features of claim 37: a method of manufacturing an optical waveguide comprising core and cladding regions comprising the steps of providing a substrate, forming a lower cladding layer on the substrate, forming a core region of said optical waveguide on the lower cladding layer, forming an upper cladding layer to cover the core region (paragraphs 45-46), wherein the whole or a part of said waveguide core and/or cladding region or regions comprise material of the stoichiometric composition $Si_aO_xN_yX_zH_v$ (paragraph 40).

The subject-matter of claim 37 therefore differs from the method of D2 in that X is selected from group of elements B, Al, P, S, As, Sb and combinations thereof, and wherein y/z is larger than 1.2 and the relative stoichiometries of the SiONXH material

are as defined in claim 1. However the use of phosphorus as a dopant in silicon oxynitride waveguides having a stoichiometry falling within the ranges defined in claim 1 is known from D1 and the choice of dopant and design of stoichiometric ratios have no influence on the basic method steps described in claim 37. Moreover, at page 15, lines 14-16 of D1 it is stated that it is possible that y is greater than z and therefore that y/z may be larger than 1.2 is considered disclosed therein. It is therefore considered that it would be obvious for the skilled person to consider the method of D2 in order to arrive at the waveguide having the material composition disclosed in D1, and therefore claim 37 does not involve an inventive step in the sense of Article 33(3) PCT.

2.2 Lack of novelty (Article 33(2) PCT) and inventive step (Article 33(3) PCT) of the dependent claims

The additional features of claims 2-9, 11-16, 20-26 are considered to be either implicitly disclosed in D1, by direct numerical derivation from the stoichiometries of the embodiments disclosed therein, or to represent obvious results of material composition optimisation that the skilled person would arrive at according to the circumstances without the exercise of inventive skill.

The additional feature of claim 27 (incorporation of a rare earth dopant) is disclosed in D1. The range of molar concentrations claimed in claim 28 is so large as to appear to attempt to cover all likely concentrations and therefore does not involve an inventive step.

The additional features of claims 29, 30, 32 and 33, namely the incorporation of TE-dopant elements for controlling the thermal expansion of the waveguide, are known from D2. The incorporation of such dopants in the waveguide material of D1 would be an obvious possibility for the skilled person in order to solve the problem posed.

The additional features of claims 38, 42-46, 48-50 and 52 are considered to represent obvious possibilities for the skilled person in the light of the disclosure of D2 and common technical knowledge in the discipline of PECVD deposition.

The additional feature of claim 53, namely incorporation of the waveguide into an optical device, is considered to be implicitly disclosed in D1. The subject-matter of the claim is therefore not new.

The additional features of claims 54 and 55 are considered to represent obvious

deployment possibilities of waveguides in general and therefore the subject-matter thereof does not involve an inventive step in the sense of Article 33(3) PCT.
The additional features of claims 10 and 45 are expressed in terms of the result to be achieved; minimisation of the loss due to absorption is obvious to the skilled person in the light of D1.
The additional feature of claims 34, 35 and 39-41 do not involve an inventive step in the sense of Article 33(3) PCT because the additional features of a buffer material (for instance of SiO_2) constituting a barrier between the core and cladding regions fully or partially surrounding the core region are known from D3 and represent an obvious design possibility for the skilled person in order to solve the problem posed.

3.1 First invention (Claims 1-30, 32-46, 48-50, 52-55)

The special technical features (STF) with respect to the closest prior art (D1) are found in claims 18, 19 and 36, namely that there are 2 elements X, where X(1) is P and X(2) is B or Ge (claim 18), or 3 elements X, where X(1) is P, X(2) is B and X(3) is Ge (claim 19), and said material further comprises Ge (claim 36).

The problem solved by the STF is how to fine-tune both the refractive index and the photosensitivity of the silicon oxynitride waveguide material.

No equivalent or corresponding STF are found in claims 31, 47 and 51.

3.2 Second invention (Claim 31)

The STF with respect to the closest prior art (D1) are found in claim 31: said TE-dopant element or elements are selected from the group of elements comprising Al, F, Ti or combinations thereof.

The problem solved by the STF is how to adjust the thermal expansion property of the silicon oxynitride waveguide material independently of the refractive index and photosensitivity tuning.

No equivalent or corresponding STF are found in claims 1-30 and 32-55.

3.3 Third invention (Claims 47, 51)

The STF with respect to the closest prior art (D2) are found in claims 47 and 51: the SiH_4 flow is in the range from 0 to 30 sccm.

The problem solved by the STF is how to minimise the hydrogen content of the deposited silicon oxynitride waveguide material in order to minimise optical absorption.

No equivalent or corresponding STF are found in claims 1-46, 48-50 and 52-55.

Mutual comparison of the above problems as seen in the light of the description and of the submitted drawings, shows that the STF solve different problems and do not provide a corresponding technical effect. Hence, the STF are also not corresponding. This applies for the different combinations of inventions. Hence, the three inventions and any combination between them are not linked by common or corresponding STF. Therefore, they define three different inventions which are not linked by a single general inventive concept as required by Rules 13.1 and 13.2 PCT. The application has been divided into the above inventions which individually are considered to meet the requirement of unity.

Re. Item V

1. The application does not meet the requirements of Article 6 PCT, because claims 1 and 37 are not clear for the following reasons:

1.1 Claim 1 has been amended to include features of former dependent claims 3-6 indicating ranges of stoichiometric values of Si, O, N and X. The claim is unclear in that, with an included zero concentration of oxygen, and furthermore an included zero of the dopant element X, the scope of the claim includes essentially pure silicon nitride (leaving aside unspecified parasitic hydrogen content). It is considered that the phrase at page 11, line 3 of the description ("Si_3N_4-like") indicates that the stoichiometry may approach, but not reach, that of pure silicon nitride. It is further considered that the application as a whole is clearly directed to materials that fall

under the general description of silicon oxynitride, i.e. those containing a finite amount of oxygen. No concrete embodiment is provided in the description of a material having no oxygen content. Therefore, for the purposes of this preliminary examination, claim 1 has been interpreted as if the relevant passage read, expressed mathematically, "x is in the range 0<x<=2.5".

1.2 Claim 37 is unclear for the same reasons as stated above with regard to claim 1, mutatis mutandis.

2. INDEPENDENT CLAIM 1

2.1 The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 1, interpreted as indicated above in §1.1 of Item V, is not new in the sense of Article 33(2) PCT.

The document D1 (references thereto are given in parentheses) discloses all the features of amended claim 1 as interpreted in the light of the lack of clarity thereof (see under Item V), namely an optical waveguide comprising core and cladding regions, the core and cladding region being formed on a substrate (pages 1-2), and the whole or a part of the core and/or cladding region comprising material of the stoichiometric composition $Si_aO_xN_yX_zH_v$, wherein X is P (phosphorus), and wherein
a is in the range from 0.1 to 3.5;
x is in the range from 0 to 2.5 [excluding zero];
y is in the range from 3.9 to 4.1 or in the range from 0.02 to 0.3;
z is in the range from 0 to 0.3 (formula at page 15, line 15);
and the ratio y/z is larger than 1.2 (page 15, lines 6-16, specifically "the over- or under-roping concentration (z-y) may be greater or smaller than zero").

The subject-matter of claim 1 is therefore not new (Article 33(2) PCT).

3 INDEPENDENT CLAIM 37

3.1 The present application does not meet the criteria of Article 33(1) PCT, because the

subject matter of claim 37 does not involve an inventive step in the sense of Article 33(3)PCT, for the following reasons:

3.2 The document D2 (references thereto are given in parentheses) discloses the following features of claim 37: a method of manufacturing an optical waveguide comprising core and cladding regions comprising the steps of providing a substrate, forming a lower cladding layer on the substrate, forming a core region of said optical waveguide on the lower cladding layer, forming an upper cladding layer to cover the core region (paragraphs 45-46), wherein the whole or a part of said waveguide core and/or cladding region or regions comprise material of the stoichiometric composition $Si_aO_xN_yX_zH_v$ (paragraph 40).

3.3 The subject-matter of claim 37 therefore differs from the method of D2 in that X is selected from group of elements B, Al, P, S, As, Sb and combinations thereof, and wherein y/z is larger than 1.2 and the relative stoichiometries of the SiONXH material are as defined in claim 1.

3.4 However the use of phosphorus as a dopant in silicon oxynitride waveguides having a stoichiometry falling within the ranges defined in claim 1 is known from D1 and the choice of dopant and design of stoichiometric ratios have no influence on the basic method steps described in claim 37. Moreover, at page 15, lines 14-16 of D1 it is stated that it is possible that y is greater than z and therefore that y/z may be larger than 1.2 is considered disclosed therein. It is therefore considered that it would be obvious for the skilled person to consider the method of D2 in order to arrive at the waveguide having the material composition disclosed in D1, and therefore claim 37 does not involve an inventive step in the sense of Article 33(3) PCT.

4 DEPENDENT CLAIMS 2-17, 20-30, 32-35, 38-46, 48-50 and 52-55

Dependent claims 2-17, 20-30, 32-35, 38-46, 48-50 and 52-55 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step (Article 33(2) and (3) PCT), for the following reasons:

4.1 The additional features of claims 2-9, 11-16, 20-26 are considered to be either implicitly disclosed in D1, by direct numerical derivation from the stoichiometries of the embodiments disclosed therein, or to represent obvious results of material composition optimisation that the skilled person would arrive at according to the circumstances without the exercise of inventive skill.

4.2 The additional feature of claim 27 (incorporation of a rare earth dopant) is disclosed in D1 and the subject-matter of the claim is therefore not new. The range of molar concentrations claimed in claim 28 is so large as to appear to attempt to cover all likely concentrations and therefore does not involve an inventive step.

4.3 The additional features of claims 29, 30, 32 and 33, namely the incorporation of TE-dopant elements for controlling the thermal expansion of the waveguide, are known from D2. The incorporation of such dopants in the waveguide material of D1 would be an obvious possibility for the skilled person in order to solve the problem posed.

4.4 The additional features of claims 38, 42-46, 48-50 and 52 are considered to represent obvious possibilities for the skilled person in the light of the disclosure of D2 and common technical knowledge in the discipline of PECVD deposition.

4.5 The additional feature of claim 53, namely incorporation of the waveguide into an optical device, is considered to be implicitly disclosed in D1. The subject-matter of the claim is therefore not new.

4.6 The additional features of claims 54 and 55 are considered to represent obvious deployment possibilities of waveguides in general and therefore the subject-matter thereof does not involve an inventive step in the sense of Article 33(3) PCT.

4.7 The additional feature of claims 34, 35 and 39-41 do not involve an inventive step in the sense of Article 33(3) PCT because the additional features of a buffer material (for instance of SiO2) constituting a barrier between the core and cladding regions fully or partially surrounding the core region are known from D3 (see abstract; Fig. 1; paragraphs [0010]-[0013], [0016]-[0021] and [0027]) and represent an obvious design possibility for the skilled person in order to solve the problem posed.

5. DEPENDENT CLAIMS 18, 19, 27, 28, 31, 36, 47, 51

The combination of the features of dependent claims 18, 19, 27, 28, 31, 36, 47 and 51 are neither known from, nor rendered obvious by, the available prior art, and consequently appear to satisfy the requirements of Article 33(1) PCT with respect to novelty (Article 33(2) PCT) and inventive step (Article 33(3) PCT). The reasons are as follows:

5.1 The additional features of claims 18, 19 and 36, namely that there are 2 elements X, where X(1) is P and X(2) is B or Ge (claim 18), or 3 elements X, where X(1) is P, X(2) is B and X(3) is Ge (claim 19), and said material further comprises Ge (claim 36). These features solve the problem of how to fine-tune the refractive index of the silicon oxynitride waveguide material; and, by means of the germanium content, how to tune the photosensitivity. There is no suggestion in the prior art to combine dopants in silicon oxynitride in this way.

5.2 The additional feature of claim 31, namely that said TE-dopant element or elements are selected from the group of elements comprising Al, F, Ti or combinations thereof, solve the problem of how to tune the thermal expansion property of the silicon oxynitride waveguide material using a separate material parameter from that/those used for fine control of absorption, refractive index, stress and photosensitivity. There is no suggestion in the prior art to combine dopants in silicon oxynitride in this way.

5.3 The following additional feature of claims 47 and 51: the SiH_4 flow is in the range from 0 to 30 sccm, solves the problem of how to minimise the hydrogen content of the deposited silicon oxynitride waveguide material in order to minimise optical absorption. The closest prior art (D2) discloses SiH_4 flow rates in the range 130-300 sccm. There is no hint therein to make such a significant reduction in the flow rate.

A LOW LOSS OPTICAL WAVEGUIDE, A METHOD OF ITS MANUFACTURE AND AN OPTICAL DEVICE

CLAIMS

1. An optical waveguide for guiding light in a predefined wavelength range, the optical waveguide comprising core and cladding regions for confining light, the core and/or cladding region or regions being formed on a substrate, and the whole or a part of the core and/or cladding region or regions comprising material of the stoichiometric composition $Si_aO_xN_yX_zH_v$, wherein
a is in the range from 0.1 to 3.5;
x is in the range from 0 to 2.5;
y is in the range from 3.9 to 4.1 or in the range from 0.02 to 0.3;
z is in the range from 0 to 0.3 and
X is selected from the group of elements B, Al, P, S, As, Sb and combinations thereof, and the ratio y/z is larger than 1.2, such as larger than 1.5, such as larger than 1.8, such as larger than 2.0, such as larger than 2.5, such as larger than 3.0, such as larger than 3.5, such as larger than 4.0, such as larger than 4.5, such as larger than 5.0, such as larger than 5.5, such as larger than 6.0, such as larger than 7.0, such as larger than 8.0.

2. An optical waveguide according to claim 1 wherein the ratio y/z is in the range from 1.2 to 100, such as 1.2 to 20, such as 1.2 to 10, such as 1.5 to 8.0, such as 2.0 to 4.0, such as 2.5 to 3.5.

3. An optical waveguide according to claim 1 or 2 wherein the number a defining the relative concentration of the element Si is in the range from 0.9 to 1.1 or in the range from 2.9 to 3.1.

4. An optical waveguide according to any one of claims 1-3 wherein the number x defining the relative concentration of the element O is in the range from 1.9 to 2.1 or in the range from 0 to 0.1.

5. An optical waveguide according to any one of claims 1-4 wherein the number y defining the relative concentration of the element N is in the range

from 3.9 to 4.1 or in the range from 0.03 to 0.2, such as in the range from 0.04 to 0.10.

6. An optical waveguide according to any one of claims 1-5 wherein the number z defining the relative concentration of the element X selected from the group comprising B, Al, P, S, As, Sb and combinations thereof is in the range from 0.005 to 0.2, such as in the range from 0.01 to 0.10.

7. An optical waveguide according to any one of claims 1-6 wherein a is in the range from 0.8 to 1.2 and x is in the range from 1.8 to 2.2 and y is in the range from 0.01 to 0.5 and z is in the range from 0.005 to 0.2.

8. An optical waveguide according to any one of claims 1-6 wherein a is in the range from 2.8 to 3.2 and y is in the range from 3.8 to 4.2 and x is in the range from 0.01 to 0.5 and z is in the range from 0.005 to 0.2.

9. An optical waveguide according to claim 1 wherein the number a defining the relative concentration of the element Si is in the range from 0.9 to 1.1, the number x defining the relative concentration of the element O is in the range from 1.9 to 2.1, the number y defining the relative concentration of the element N is in the range from 0.015 to 0.12, and the number z defining the relative concentration of the element X is in the range from 0.005 to 0.04.

10. An optical waveguide according to any one of the preceding claims wherein the optical absorption peak at λ=1508 nm due to Si:N-H bonds is smaller than 0.1 dB/cm, such as smaller than 0.05 dB/cm such as smaller than 0.01 dB/cm.

11. An optical waveguide according to any one of the preceding claims wherein the number v defining the relative concentration of the element H is such that the relative concentration v/(a+x+y+z+v) of H in $Si_aO_xN_yX_zH_v$ is smaller than 10^{-2}, such as smaller than 10^{-3}, such as smaller than 10^{-4}, such as smaller than 10^{-5}.

12. An optical waveguide according to any one of the preceding claims wherein the atomic concentration of hydrogen is larger than the atomic concentration of nitrogen and/or phosphorus.

13. An optical waveguide according to any one of the preceding claims wherein the atomic concentration of hydrogen is larger than 5 at.%.

14. An optical waveguide according to any one of the preceding claims wherein the number v defining the relative concentration of the element H is such that the concentration v/y of H relative to N is smaller than 10^{-2}, such as smaller than 10^{-3}, such as smaller than 10^{-4}.

15. An optical waveguide according to any one of the preceding claims wherein the number v defining the relative concentration of the element H is such that the concentration v/z of H relative to X is smaller than 10^{-2}, such as smaller than 10^{-3}, such as smaller than 10^{-4}, X being an element selected from the group comprising B, Al, P, S, As, Sb and combinations thereof.

16. An optical waveguide according to any one of the preceding claims wherein the element or elements X or the material $Si_aO_xN_yX_zH_v$ comprises at least 50% phosphorus such as at least 75% phosphorus such as at least 90% phosphorus, such as 100% phosphorus.

17. An optical waveguide according to any one of the preceding claims wherein the element or elements X or the material $Si_aO_xN_yX_zH_v$ comprises at least two elements X(1), X(2), ..., X(n) where $n \leq 7$, selected from the group comprising B, Al, P, S, Ge, As, Sb of relative concentration z_1, z_2, ..., z_n, respectively, where $z=z_1+z_2+z_3+...+z_n$ and wherein z_1/z is larger than 0.50 such as larger than 0.75 such as larger than 0.90.

18. An optical waveguide according to claim 17 wherein n=2 and X(1) is P and X(2) is B or Ge.

19. An optical waveguide according to claim 17 wherein n=3 and X(1) is P, X(2) is B and X(3) is Ge.

20. An optical waveguide according to any one of the preceding claims wherein the waveguide core and/or cladding layers comprise material of the stoichiometric composition $Si_{(1-z)}O_{(2-y)}N_yX_z$ wherein X is an element form the group comprising B, Al, P, S, As, Sb or a combination thereof.

21. An optical waveguide according to claim 20 wherein X is P.

22 An optical waveguide according to claim 20 or 21 wherein $0 < y \leq 0.2$ and $0 < z \leq 0.1$.

23. An optical waveguide according to any of the preceding claims wherein the atomic density of silicon $N_{at}(Si)$ is in the range $4.5 \cdot 10^{21} < N_{at}(Si) < 1.3 \cdot 10^{22}$, such as in the range $5.1 \cdot 10^{21} < N_{at}(Si) < 9.1 \cdot 10^{21}$, the atomic density of oxygen $N_{at}(O)$ is in the range $9.0 \cdot 10^{21} < N_{at}(O) < 2.7 \cdot 10^{22}$, such as in the range $1.0 \cdot 10^{22} < N_{at}(O) < 1.8 \cdot 10^{22}$, the atomic density of nitrogen $N_{at}(N)$ is in the range $0 < N_{at}(N) < 2.7 \cdot 10^{21}$, such as in the range $0 < N_{at}(N) < 1.8 \cdot 10^{21}$, and the atomic density of phosphorus $N_{at}(P)$ is in the range $0 < N_{at}(P) < 1.3 \cdot 10^{21}$, such as in the range $0 < N_{at}(P) < 9.0 \cdot 10^{20}$.

24. An optical waveguide according to any one of the preceding claims wherein the core and/or cladding region comprises material having a refractive index at a wavelength of 1550 nm in the range 1.45 – 2.02, such as in the range from 1.45 to 1.60, such as in the range from 1.48 to 1.56.

25. An optical waveguide according to any one of the preceding claims wherein the optical waveguide is adapted to guide light in a wavelength range from 250 nm to 3.6 μm, such as in the range from 850 nm to 1800 nm.

26. An optical waveguide according to any one of the preceding claims wherein the optical waveguide is adapted to guide light comprising wavelengths in the range from 1260 nm to 1660 nm, such as in the range 1530-1565 nm, or in the range 1460-1530 nm, or in the range 1360-1460 nm, or in the range 1260-1360 nm.

27. An optical waveguide according to any one of the preceding claims wherein the waveguide core and/or cladding further comprises a rare earth

elements selected from the group of elements comprising Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu or combinations thereof.

28. An optical waveguide according to any one of the preceding claims wherein one or more of the rare earth elements are present in molar concentrations in the range from 50 to 5000 ppm mole/mole.

29. An optical waveguide according to any one of the preceding claims wherein the core and/or cladding region further comprises one or more TE-dopant elements for controlling the thermal expansion of the waveguide.

30. An optical waveguide according to any one of the preceding claims wherein the thermal expansion of one or more of the layers constituting the core and cladding regions of the waveguide is/are adapted to the thermal expansion of the substrate by adding one or more TE-dopant elements to said one or more layers of the waveguide.

31. An optical waveguide according to claim 29 or 30 wherein said TE-dopant element or elements are selected from the group of elements comprising Al, F, Ti, or combinations thereof.

32. An optical waveguide according to any one of claims 29-31 wherein said TE-dopant element or elements are present in the core/and or cladding region or regions in molar concentrations in the range from 0 to 5%.

33. An optical waveguide according to any one of claims 29-32 wherein said dopant element or elements are present in the core/and or cladding region or regions in amounts sufficient to provide a coefficient of thermal expansion between 1×10^{-7} °C^{-1} and 15×10^{-7} °C^{-1}.

34. An optical waveguide according to any one of the preceding claims comprising a buffer material constituting a barrier between the core and cladding regions and fully or partially surrounding said core region.

35. An optical waveguide according to claim 34 wherein said buffer material is selected from the group SiO_2, Si_xN_y, such as Si_3N_4, PECVD BPSG with alternative B/P doping levels and combinations thereof.

36. An optical waveguide according to any one of the preceding claims wherein said material further comprises Ge.

37. A method of manufacturing an optical waveguide according to any one of claims 1-36,
the method comprising the steps of
A) providing a substrate,
B) forming a lower cladding layer on the substrate,
C) forming a core region of said optical waveguide on the lower cladding layer,
D) forming an upper cladding layer to cover the core region and the lower cladding layer.

38. A method according to claim 37 wherein step C) comprises the sub-steps
C1) forming a core layer on the lower cladding layer,
C2) providing a core mask comprising a core region pattern corresponding to the layout of the core region of said optical waveguide, and
C3) forming core regions using the core mask, a photolithographic and an etching process.

39 A method according to claim 37 or 38 wherein a sub-step
C4) of forming a barrier layer on top of said core region pattern, and optionally on top of the lower cladding layer not covered by the core region pattern;
is inserted before step D)

40. A method according to claim 38 or 39 wherein a sub-step C0) of forming a barrier layer on top of said lower cladding layer is inserted before step C1).

41. A method according to claim 39 or 40 wherein a sub-step of annealing is inserted after said barrier forming step or steps C0) and/or C4)

42. A method according to any one ofclaims 37-41 wherein the substrate is a silicon or quartz substrate.

43. A method according to any one of claims 37-42 wherein the formation of layers on the substrate is made by plasma enhanced chemical vapour deposition.

44. A method according to claim 43 wherein a standard cluster tool CVD process chamber type PECVD-apparatus from Surface Technology Systems is used for the formation of layers on the substrate.

45. A method according to claim 43 or 44 wherein processing parameters of the PECVD-process are optimized with a view to minimizing the optical absorption around λ=1508 nm.

46. A method according to any one of claims 43-45 wherein processing parameters to be optimized include one or more of the following:

a) SiH_4 flow;
b) the N_2O flow;
c) the N_2 flow;
d) the NH_3 flow;
e) the power;
f) the pressure;
g) the temperature;
h) the frequency;
i) the flow or flows comprising the element or elements X;

47. A method according to any one of claims 43-46 wherein

a) the SiH_4 flow rate is in the range from 0 to 30 sccm, such as 10 to 30 sccm;

b) the N_2O flow rate is in the range from 0 to 1000 sccm, such as 100 to 400 sccm;

c) the N_2 flow rate is in the range from 0 to 3000 sccm, such as 1000 to 3000 sccm.

d) the NH_3 flow rate is in the range from 0 to 300 sccm, such as 150 to 250 sccm;

e) the power is in the range from 0 to 1000 W, such as 400 to 1000 W.

f) the pressure is in the range from 100 to 500 mTorr, such as 200 to 500 mTorr.

g) the temperature is in the range from 200 to 500 °C, such as 200 to 400 °C.

h) the frequency is around 380 kHz or around 13.8 MHz.

48. A method according to claim 46 or 47 wherein the X=P and in i) the PH_3 flow is provided by PH_3 diluted in N_2 or another carrier gas.

49. A method according to claim 48 wherein in i) the PH_3 flow is provided by 5% PH_3 in N_2 with a flow rate of 0 to 50 sccm such as 2 to 20 sccm.

50. A method according to claim 46 or 47 wherein X comprises P and in i) the PH_3 flow is provided by PH_3 diluted in N_2 or another carrier gas and wherein the PH_3 flow value is used as a stress optimization parameter for the core region.

51. A method according to any one of claims 43-50 wherein processing parameters of the PECVD process essentially have the following values:

a) SiH_4 flow rate 20 sccm;

b) the N_2O flow rate 100-400 sccm;

c) the N_2 flow rate 2000 sccm;

d) the NH_3 flow rate is 100 sccm;

e) the power is 700 W;

f) the pressure is 250 mTorr;

g) the temperature 350 °C;

h) the frequency is 380 kHz;

i) 5%PH_3 in N_2 flow rate 10 sccm;

52. A method according to any one of claims 46-51 wherein in step i) the flow gas is selected among the group of gases SiH_4, SiF_4, $SiCl_4$, SiF_4, Si_2H_6,

SiH_2Cl_2, $SiCl_2F_2$, SiH_2F_2, N_2O, NO, N_2, NO_2, O_2, H_2O, H_2O_2, CO, CO_2, N_2O, NO, N_2, NO_2, NH_3, N_2, B_2H_6, AlH_3, PH_3, H_2S, SO, SO_2, GeH_4, AsH_3, or combinations thereof.

53. An optical device comprising an optical waveguide as defined in any one of claims 1-36.

54. An optical device according to claim 53 comprising a branching component, such as a splitter or an arrayed waveguide grating.

55. An optical device according to claim 53 or 54 comprising an optical duplexer or triplexer.